Chapter 23
Incineration

23-1. General

The process and applications of incineration are described in the chapter's first section. The second portion of the chapter is a hazard analysis with controls and control points listed.

23-2. Technology Description

a. Process.

Incineration is a treatment process for contaminated soil, sludges, sediments, and liquids using extreme heat to oxidize organic materials (incineration of vapor streams is discussed in Chapter 24). Materials are heated to a specified temperature, usually at least 1800°F, for a specified time, usually at least 1 second at temperature, to oxidize the contaminants. The appropriate temperature and residence time depends on the nature of the waste stream and contaminants. A gaseous or liquid fuel provides the energy for the oxidation. Oxygen is supplied from air or pure oxygen feeds. The products of combustion are carbon dioxide, water, and depending on the feed, acid gases, metal oxides, and noncombustible ash.

While the treatment process is simple and reliable, there are stringent requirements for controlling vapor emissions from the incinerator that significantly increase the complexity of the process. Each additional treatment step also introduces unique hazards to the overall process. The exhaust from the treatment usually includes controls for particulates, ash, and combustion products (carbon monoxide, halogens released during combustion, and hydrocarbons). The ash usually requires handling and disposal as a hazardous waste material and is sent to special landfills for this purpose. The particulates are removed using either bag houses or electrostatic precipitators, but can also be removed by wet scrubbers. Dust is usually handled in the same fashion as ash. In addition, acid gases that form when oxidizing halogenated compounds must be removed in acid gas scrubbers. Uncontrolled acid gases can cause serious physical damage to equipment and pose significant hazards to workers. In addition, owing to the acid nature of the gasses, the water stream generated by the scrubber becomes acidic and must be handled and disposed of safely. See Figure 23-1.

b. Applications.

The incineration process is applicable to a wide range of waste streams, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, solvents, polychlorinated biphenyls (PCBs), virtually all fuel and tar streams, and combinations of these compounds. It is very effective in terms of percentage of destruction of the compounds of concern. The feed to the incinerator is usually a liquid or a solid but can be a combination. Sludges, semi-solids, and cakes may be effectively treated, provided the feed handling system can convey these materials to the unit. Oversized solids (rocks, large chunks) may be removed by screening devices before the material is fed into the combustion chamber.

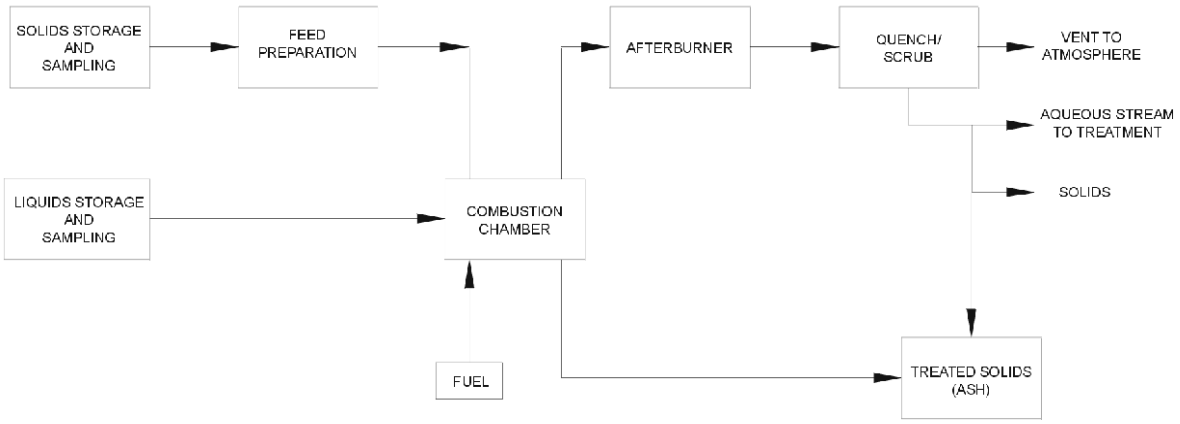

FIGURE 23-1. TYPICAL PROCESS FLOW FOR INCINERATION

23-3. Hazard Analysis

Principal unique hazards associated with incineration, methods for control, and control points are described below

a. Physical Hazards.

(1) *Noise Hazards*.
Description. Incineration may cause elevated noise levels in the work area because of the operation of air blowers, pumps, induced draft and exhaust fans, high energy venturi scrubbers, fuel injection ports, and the ignition of fuels within the combustion chamber. The noise level can interfere with safe and effective communications.

Control. Controls for noise hazards include:

- Refer to UFGS 02180A, "Remediation of Contaminated Soils and Sludges by Incineration" for noise control.
- Train workers in the use of hearing protection and establish a hearing conservation program (see 29 CFR 1910.95).
- Use personal electronic communications devices, such as a dual ear headset with speaker microphone, to overcome ambient noise where communication is critical in high noise areas. Hearing protection/headset combinations are commercially available and should be used where needed.
- Establish vibration and noise-free areas during operations to provide breaks from the vibration and noise, which can cause fatigue and inattention.

CONTROL POINT: Design, Operations

(2) *Heat and Pressure Buildup.*

Description. The incineration process may cause solid waste material to vitrify into a large, hot mass within the unit. The resulting heat and pressure buildup may exceed design specifications of the unit, damage the unit, and result in explosive release of waste materials and expose personnel and the public to chemical and physical hazards. Both heated or cooled vitrified material in the units may break away and seriously injure or kill workers who enter the units.

Control. Controls for heat and pressure buildup include:

- Prepare a Design Safety Analysis Plan. Follow operating instructions in UFGS 02180A, "Remediation of Contaminated Soils and Sludges by Incineration" (Section 1.2.2.3 of the standard addresses slagging control requirements). The standard also requires the following plans:
- A Mobilization Plan containing the specific procedures and requirements for on-site placement of the incineration system and subsystems.
- A Startup Plan providing a sequence of detailed procedures, calibrations, tolerances and schedules, control system functions, actions, reactions (both mechanical and chemical) occurring manually or automatically, as the system components are engaged to test the system with uncontaminated materials (a trial burn or mini burn) or used to begin a new sequence of operation.
- Utilize a System Safety Record of Documentation during the trial burn plan required by the Startup Plan. The System Safety Documentation Record shall present optimal operating conditions and allowable variances that shall be continuously monitored and recorded along with required sampling and analysis to support the record.
- A Permit-Required Confined-Space Entry Plan including pre-entry unit cool down procedures and shutdown verification prior to doing maintenance on the unit openings or interiors.
- Operate the unit within the design and control parameters.
- Design controls that prevent unit entry until all material has cooled.
- Train the operators in standard operation and emergency procedures in the event of a catastrophic failure, in life saving first aid procedures including halting reactions, extracting, extinguishing, decontaminating and stabilizing victims, and in emergency system isolation and shutdown procedures.
- Locate emergency fire fighting equipment, eyewashes, and showers at critical points throughout the system. (See American National Standards Institute ANSI Z358.1 – 1998.)
- Perform a Process Hazard Analysis (PHA) prior to initial startup and correct all deficiencies found.
- A Demobilization Plan, including decontamination and disassembly requirements.

CONTROL POINT: Design, Operations, Maintenance

(3) *Flammable/Combustible Fuels.*

Description. Incinerators usually require storage of flammable or combustible fuels (e.g., kerosene, waste fuels) used to fire the incinerator. Hazards associated with fuels include the potential for an on-site spill or release of material. The release may cause worker exposure to the liquid state or vaporized fuels, or a fire hazard may exist if the material is ignited.

Control. Controls for flammable/combustible fuels include:

- Use appropriate tanks, bermed and equipped with pressure-relief devices to help prevent release of material.
- Use electrical equipment and fixtures that comply with NFPA 70.
- Meet mandatory requirements of NFPA 30, "Flammable and Combustible Liquids Code," NFPA 31, "Installation of Oil Burning Equipment," NFPA 54, "National Fuel Gas Code," or NFPA 58, "Standard for the Storage and Handling of Liquefied Petroleum Gases" for fuel system installation, storage, and testing.
- Ventilate the storage area adequately to help prevent the accumulation of flammable vapors.
- Permit only trained and experienced workers to work on the incinerator.
- Use lock-out and tag-out procedures on all electrical systems during repair or maintenance in the storage area.

CONTROL POINT: Design, Operations, and Maintenance

(4) *Ignition of Saturated Soils*.

Description. During excavation of waste materials with low flash points, saturated soils may be ignited by sparks generated when the blade of the dozer or crawler contacts rocks or other objects under unusual or extraordinary conditions. If the soil will be crushed prior to feeding into the incinerator, waste materials with high Btu values may ignite during the crushing/sorting process.

Control. Controls for ignition of saturated soils include:

- Apply water periodically to the soil (before and during crushing).
- Use professional judgment on evaluating the site, work equipment, soil, and ambient work conditions, and, if necessary, equip soil-handling equipment with non-sparking buckets or blades when highly flammable incineration feed soils or materials are suspected.

CONTROL POINT: Operations

(5) *Electrocution*.

Description. As incinerators operate electrical systems outdoors, workers may be exposed to electrocution hazards if the electrical equipment contacts water, or any of the subunits are not properly grounded.

Control. Controls for electrocution include:

- Verify that drawings indicate the hazardous area classifications as defined in NFPA 70, 500-1 through 500-10.

- Use controls, wiring, and equipment that meet the requirements of EM 385-1-1, Section 11, and NFPA 70.
- Use adequate ground-fault protection.
- Never allow the use of ungrounded temporary wiring for minor maintenance work on the units, nor wiring not approved for contact with water or on wet or damp surfaces.

CONTROL POINT: Design, Construction, Operations, Maintenance

(6) *Incinerator Operation*.
Description. Workers may be exposed to toxic waste chemicals or combustion gases via inhalation if high-Btu waste material is fed into the incinerator at a rate that exceeds its design capacity. This may over-pressurize the system, resulting in a release of both combustion gases and unburned or partially burned waste material vapors into worker areas.

Control. Controls for incinerator operation include:
- Use experienced operators and supervisors.
- Audit and apply proper quality assurance/quality control (QA/QC) to assure work is done as designed.
- Operate the system and waste material within design parameters.
- Perform a Process Hazard Analysis (PHA) prior to startup and correct all deficiencies found.

CONTROL POINT: Design, Operations

(7) *Incineration System Design*.
Description. The incineration process can use one piece of equipment with two or more additional waste processing units attached. Most waste incinerators include equipment similar to thermal desorption units for handling materials at the inlet and outlet of the unit. There may be exhaust gas conditioning equipment, such as electrostatic precipitators, bag houses, vapor scrubbers, or catalytic converters, added to incinerators. Each piece of equipment has its own hazards, such as confined space. The Environmental Protection Agency (EPA) regulates design requirements for incinerators. Process requirements are specified to eliminate contaminant releases that can cause exposure to site workers and the public. In addition, each manufacturer also publishes guidelines for assuring safe operation and maintenance.

Control. Controls for the incineration system include:
- Include the subject of hazard control in design to address all the individual sub-systems in the overall system.
- Perform a Process Hazard Analysis (PHA) prior to initial startup and correct all deficiencies found.
- Design the incineration process according to EPA and manufacturer requirements. Consult OSHA 29CFR 1910.146 “Permit-required Confined Spaces” and minimize the use of confined spaces in design. Design

requirements should meet UFGS 02180A, "Remediation of Contaminated Soils and Sludges by Incineration."

CONTROL POINT: Design

(8) *Transfer Equipment Design*.
Description. Improperly designed systems can corrode or dissolve to a point of failure and cause damage to the facilities or exposure to workers.

Control. Controls for transfer equipment design include:
- Consult EM 1110-1-4008, "Liquid Process Piping," and UFGS 15200A, "Liquid Process Piping," for appropriate materials for pumping various fluids.
- Use equipment fabricated from materials that are chemically inert to the waste chemicals and materials being transferred.
- Install spill leak detection instruments, including alarms if necessary.
- Include containment drip pans or receivers for potential leaks and spills.
- Implement preventive maintenance program and complete periodic inspections.

CONTROL POINT: Design, Construction, Maintenance

(9) *Burn Hazards*.
Description. Workers may be exposed to burn hazards to the skin from hot ash during operation and maintenance of the incinerator.

Control. Controls for burn hazards include:
- Design the incinerator and post-incineration exhaust gas treatment units to maximize ease of operation, physical cleaning, and maintenance to include adequately sized and easy access doors and ports where entry is required.
- Perform manufacturer's shutdown and cool down procedures prior to working on, around, or entering incinerator or post-incineration treatment units.
- Use penetrating temperature probes to measure internal temperatures of ash accumulations prior to incinerator or treatment unit entries. Verify that internal ash temperatures are ambient prior to entry into units to work.
- Develop confined space entry permit and rigorously apply requirements.
- Verify function, and use manufacturer's temperature safety control systems.
- Design the incinerator ash handling system to efficiently transport solid waste and ash materials exiting the system so as to avoid creating buildup of hot waste materials within the system.
- Install safety barriers to isolate critical sections of the equipment.
- Post signs warning of high temperatures.
- Train workers in hazards; use heat-resistant gloves, eye and skin protective gear, and permit system maintenance only after process equipment has cooled to the manufacturer's stated safe temperature.

CONTROL POINT: Design, Operations, Maintenance

(10) *Transfer Systems*.
Description. Transfer systems, such as feed belts, augers, screw conveyors, etc., expose workers to injury if limbs or clothing are caught in the system.

Control. Controls for transfer systems include:

- Enclose or otherwise guard transfer system pinch points, such as belts, pulleys, and conveyor end points, or material transfer points to the maximum extent possible.
- Install color coded labeled emergency shutoff controls at multiple critical locations. Train workers on the shutoff control locations and operation. Post signs if necessary.
- Train workers in acceptable use of hand tools. Lock-up or otherwise remove unnecessary shovels, poles, or hand tools that may be used by workers as dislodging tools.
- Enforce lock-out/tag-out procedures rigorously.
- Train workers to identify pinch points in the system.

CONTROL POINT: Design, Operations, Maintenance

(11) *Piping System Leaks*.
Description. Workers may be exposed via inhalation to components of waste fuels such as VOCs, e.g., toluene, if leaks occur in the pressurized section of the piping system.

Control. Controls for leaks in the piping system include:

- Design the system to operate under a negative pressure (e.g., ducts and piping) for the maximum operating pressure expected.
- Avoid or minimize fugitive emission hazards by designing pressure control mechanisms and appropriate relief systems.
- Install and test fuel systems according to requirements of NFPA 30, "Flammable and Combustible Liquids Code," NFPA 31, "Installation of Oil Burning Equipment," NFPA 54, National Fuel Gas Code," or NFPA 58, "Standard for the Storage and Handling of Liquefied Petroleum Gases."

CONTROL POINT: Design, Operations, Maintenance

(12) *Heated Surfaces*.
Description. Workers may be exposed to infrared radiation hazards associated with working in the vicinity of incinerators. The exposure, depending on the temperature of the equipment, length of exposure, and other variables may increase the risk of cataracts or heat stress.

Control. Controls for heated surfaces include:

- Minimize worker exposure time on or near hot equipment surfaces.

- Use eye protection with the appropriate shade safety glass and reflective radiant heat protective suits if prolonged work near the radiant heat surface or source is required to control both eye and body exposure.
- Shield affected work areas.

CONTROL POINT: Operations, Maintenance

(13) *Sunlight/UV Radiation.*
Description. During site activities, workers may be exposed to direct and indirect sunlight. Even short-term exposure to sunlight can cause dermal damage and burns. Hot and humid conditions can increase the risk of heat-related injury as heat exhaustion, cramps, or heat stroke.

Control. Controls for Sunlight, UV radiation and heat stress include:
- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length unbloused pants, and by applying UV barrier sunscreen to exposed skin. Loose clothing and sun hats should not be worn around moving parts that may snag the worker and draw him into a danger zone. All UV skin barrier creams should be pre-approved. Some creams contain zinc and other constituents that can cause false readings in analytical samples.
- Shade work and break areas, if possible.
- Minimize exposure to heat stress by training the workers in the symptoms of heat stress, practicing the Buddy System, taking frequent breaks, drinking adequate fluids, and working during the cooler part of the day.
- Monitor for heat stress using the physiological or Wet Bulb Globe Temperature (WBGT) Index protocol provided in the most recent publication of the American Conference of Governmental Industrial Hygienists (ACGIH) "TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices."

CONTROL POINT: Construction, Operations, Maintenance

(13) *Respirable Quartz.*
Description. If soil is the material incinerated, exposure to respirable quartz may be a hazard. Consult geology staff to confirm the presence of quartz in feed materials. To determine respirable quartz exposure potential, sample and analyze site soils and ash for fines content by ASTM D422 (R2002) "Standard Test Method for Particle Size Analysis of Soils" followed by analysis of the fines by X-ray diffraction to determine crystalline silica quartz content.

Control. Controls for respirable quartz include:
- Eliminate dust generation or escape of dust from equipment into worker's air spaces and breathing zones. Install water mist systems on the equipment at dust escape points. Wet the soil periodically with water or amended water to minimize dust generation and worker exposure.

- Consult 29 CFR 1910.1000, Table Z-3, to calculate acceptable respirable dust concentrations based on percent silica in the quartz.
- Where engineering controls fail, use respiratory protection such as air-purifying respirators equipped with an N, R or P100 particulate filter and train workers in respirator use.
- Train workers in potential inhalation hazards from crystalline silica quartz laden dust.

CONTROL POINT: Operations, Maintenance

(14) *Confined Spaces.*

Description. Workers may be exposed to confined-space hazards when entering the process equipment for inspection, maintenance or repair. Incineration systems typically have multiple treatments subunits to treat the exhaust combustion gases that range in physical and operational complexity, such as the incinerator itself, dust/gas collection/ventilation duct work, electrostatic precipitators (ESP), cyclones, high energy wet scrubbers and bag houses, which can be operated under high temperature, oxygen deficient, toxic, inert, and negative air conditions. All treatment units that require periodic entry for maintenance present significant confined space hazards. The treatment train dust collection units typically operate at high temperatures generated in the incinerator. Ash and dust suctioned from the incinerator can accumulate in the ESP, bag house, or cyclone feed duct and collection hoppers. Hot ash can retain its fluid and thermal properties for an extended period of time, even many days after shutdown. Confined space hazards may include death or injury by sudden release of hot or vitrified waste ash or material in the units during maintenance, such as caused by prematurely opening hopper doors. Before entry, assurance must be made that no accumulations of ash are impounded behind the doors. Death or injury can be caused by inhalation exposure to inert gas, severe oxygen deficiency, toxic combustion byproducts, or poisonous gases volatilized from the treated materials, including heavy metals, H_2S, CO, methane, vinyl chloride, etc., and entanglement or electrocution.

Control. Controls for confined spaces include:

- Design the incinerator and exhaust gas treatment systems to maximize easy operation, and physical cleaning and maintenance to include accessible, adequately sized access doors and ports; and to minimize the frequency, duration, and extent of cleaning and maintenance required.
- Develop a pre-entry confined space permit (see 29 CFR 1910.146).
- Test the atmosphere within the confined space prior to entry and monitor throughout the work (see 29 CFR 1910.146).
- Design air-handling systems to minimize or eliminate oxygen-deficient locations and rigorously ventilate prior to entry of personnel.
- Perform the manufacturer’s shutdown procedures and lock-out/tag-out of electrically energized systems, such as for the ESP or bag house, prior to entry.

- Ash collection hoppers must be inspected internally from above to determine the buildup of ash in corners or valleys prior to opening hopper doors. The doors should be connected to the electrical interlock system for the ESP, bag house, or cyclone. If the hopper must be entered, all ash must be dislodged and discharged prior to entry, i.e., use a mechanical vibrator, or poke, prod or air lance followed by washing with high-pressure water hose. Hoppers must never be opened during operation of the collection unit because of ash temperature and fluidity.
- Use penetrating temperature probes to measure internal temperatures of ash buildup or piles, such as in the dust collection unit hoppers, prior to opening or entering the units. Identify the locations of all accumulations of ash or vitrified ash in the units through soundings, measuring concentrations of background radioactive contaminants, or other methods prior to entry.
- Use air-supplied respirators to control inhalation exposures to toxic chemicals and prevent any potential for asphyxiation in situations where only constant mechanical ventilation prevents the buildup of a toxic or inert gas environment.

CONTROL POINT: Design, Operations, Maintenance

(15) *Emergency Wash Equipment.*
Description. Emergency shower/eyewash equipment required per 19 CFR 1910.151 is not always provided with adequate floor drains, thereby creating potential electrical hazards or walking surface hazards during required testing and use.

Control. A control for emergency wash equipment includes:
- See American National Standards Institute ANSI Z 358.1 – 1998: "Emergency Eyewash and Shower Equipment" for design requirements.
- Equip showers/eyewash equipment with accompanying functional drains to isolate and collect the shower/eyewash water from unprotected electrical equipment and walking surfaces that, when wet, create slipping hazards.

CONTROL POINT: Design

(16) *Design Field Activities.*
Description. Design field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminated groundwater sampling, and other activities. Each of these field activities may expose the survey personnel to physical, chemical, radiological, and biological hazards.

Control. Controls for hazards resulting from design field activities include:
- Prepare an activity hazard analysis for design field survey activities. EM 385-1-1, Section 1, provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design

b. Chemical Hazards.

(1) *Waste Material Exposure (Excavation and Transport).*
Description. Worker exposure may occur during excavation, transport, or handling of waste materials. Dry soils may generate airborne dusts contaminated with toxic materials, including and in addition to those contaminants being treated (e.g., respirable quartz, pesticides, etc.).

Control. Controls for waste material exposure include:

- Train the workers in the hazards, engineering controls, personal protective equipment, and good personal hygiene practices effective in protecting against exposure to the contaminants of the materials being transported.
- Routinely wet waste material and dirt/gravel travel routes to prevent airborne dust generation.
- Use respiratory personal protection equipment (PPE) such as air supplied, or air-purifying respirators with appropriate filter/cartridges such as N, R or P100 particulate air filters, OV cartridges for vapors, or combination filter/cartridges for dual protection.

CONTROL POINT: Operations

(2) *Toxic Material Exposure (Feed or Byproducts).*
Description. During operation of the incinerator, workers may be exposed to toxic materials in the feed, byproducts of combustion, oxygen deficient atmospheres, high levels of carbon dioxide, carbon monoxide, or to airborne toxic materials, including heavy metals, metal acetates, mercury, and halogens such as chlorine from halogenated hydrocarbons in wastes being incinerated. In addition, toxins such as dibenzofurans and dioxins may also be generated during the process. Post-incineration units within the system that utilize bulk chemical additives or sludge additives in conjunction with exhaust gas wet scrubbers, preclarifier mixing tanks, filter press pre-coat tanks, or surge tanks may present significant exposure potentials, both when the chemicals are replenished and when routine maintenance is performed on the units.

Control. Controls for exposure to toxic material include:

- Train all workers involved in both the operation and maintenance of the incinerator in all chemical hazards related to the generation, transport, and treatment of the contaminants, contaminant byproducts within the system, and the bulk chemical additives used to treat the contaminants.
- Characterize and classify wastes to be treated prior to incineration.
- Use only those waste materials compatible with the process managed in the unit.

- Note design parameters on feed characteristics and meet the requirements of UFGS 02180A "Remediation of Contaminated Soils and Sludges by Incineration."
- Design engineering controls for the system to prevent or minimize the generation or release of toxic materials or gases into the breathing zone of the workers, both during operation and maintenance. The engineering controls could include negative air throughout the treatment system, dust misting systems at strategic points throughout the system, real time monitors with alarms, and contaminant exposure badges.
- Select the appropriate technology for the known or anticipated wastes.
- Use appropriate ventilation controls.
- Install, locate, and maintain emergency fire fighting and eyewash and emergency showers at critical points throughout the system. (See ANSI Z 358.1 – 1998.)
- Use PPE appropriate to the contaminants and treatment byproducts, such as thermal protective gear, safety glasses, face shields, protective gloves, air-supplied respirators or air-purifying respirators equipped with filters/cartridges appropriate for the contaminants of concern and air emission controls.

CONTROL POINT: Design, Operations, Maintenance

c. Radiological Hazards.

Radioactive Devices.
Description. Fire and smoke detection devices and other process monitors and switches may contain radioactive devices potentially exposing workers through lack of identification or mishandling.

Control. Controls for inadvertent handling or exposure to radioactive devices include:
- Workers should be prevented from and warned against tampering with the devices.
- The location of the devices should be recorded so as to safely retrieve and dispose of them in case of a system failure and equipment replacement.

CONTROL POINT: Design, Operations and Maintenance

d. Biological Hazards.

Opportunistic Insects and Animals.
Description. For all sites but especially in cooler climates, opportunistic insects or animals can nest in and around warm process equipment. Vermin, insect, and arthropod control measures should be considered in any design.

Control. Controls of opportunistic insect and animals include:
- Electrical cabinets and other infrequently opened enclosures should be opened carefully and checked for black widow and brown recluse spiders, and evi-

dence of rodents. As rodents can cause damage to electrical cables, all wiring should be inspected regularly.

- Ensure all storage is off the ground, palleted, and kept dry. Damp areas attract scorpions, rodents, and the snakes that eat them.
- Design ceiling corners and other high areas to discourage nesting by swallows, pigeons, and other birds. Birds are carriers of diseases, especially in their droppings, which can foul process equipment.

CONTROL POINT: Design, Operations and Maintenance